PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Electrical Power-transmitting Set.

I, JACQUES DE JONG, Manufacturer, of 114, Avenue Jan Van Rijswijk, Antwerp, Belguim, of Belgian nationality, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to an improved electrical set for the transmission of power generally, and more particularly intended for application to motor vehicles.

The said set principally comprises:

1. An electrical machine capable of serving either as a dynamo or as a motor, and of which the field-magnet and the armature are both rotatable;

2. An electrical machine also capable of serving either as a dynamo or a motor, but of which the field-magnet is stationary and the armature rotatable;

3. A set of planetary gearing of which one of the elements is related both to the first motion shaft of the set to which the power is transmitted to the set and to the movable field-magnet of the first electrical machine, while a second element is similarly related to the shaft carrying the armatures of the two electrical machines and the third element is related to the driven shaft of the set, which is subjected to the load, that is to say, to the shaft transmitting the power to the rear wheels in the case of the application of the invention to a motor vehicle.

It follows that owing to the interposition of the said planetary gearing between the power and the load the electrical portion of the transmission is not required to transmit the total effort, so that for the transmission of an initial force of given value, the electrical elements of the set according to the invention may be appreciably more reduced in weight and dimensions than those of existing sets of purely electrical transmission gear.

[Price 1/-]

The slip produced between the field-magnet and the armature of each of the two machines is employed to produce current either for magnetic clutching, for which purpose one of the electrical machines is short-circuited upon itself, or to operate the other machine as an auxiliary motor, thus avoiding any loss of energy in both forward and reverse drives.

In the accompanying drawings:

Fig. 1 shows, by way of example only, a longitudinal section of one embodiment of the power transmitting set according to the invention, it being expressly understood that any other type of planetary gearing than that illustrated may be employed, as the particular type to be adopted may vary according to the requirements of each individual case.

Fig. 2 illustrates, in a purely diagrammatic manner only, an arrangement for the application of the electrical power-transmitting set according to the invention for the purpose of battery charging and engine starting.

Referring to the said drawings, and more particularly to Fig. 1, the first motion shaft 1 is fixedly secured or coupled to the end cover plate 2 fixedly mounted on the field-magnet 4 of an electrical machine A (a dynamo-motor of the series-wound type), of which the armature is indicated by the numeral 11.

B is a second electrical machine (also a dynamo-motor of series-wound type) of which 12 indicates the armature and 13 the field-magnet.

The end cover plate 2 and the field-magnet 4 carry a shaft or an annular series of shafts 3 on which are rotatably mounted satellite pinions, each constituted by two spur-pinions 7 and 8 integral with each other. The pinions 7 mesh with a spur-pinion 6 rigidly secured on or integral with the adjacent end of the driven shaft 5, while the pinions 8 mesh with a spur-pinion 9 provided on the

adjacent end of a hollow shaft 10 concentric with the driven shaft 5 and carrying the armatures 11 and 12.

The field-magnet 4 of the machine A being rotatable, the excitation coils and the brushes of the said machine are connected to rings 14 on which are arranged wiper contacts or brushes through which all the electrical connections required for the working of the field-magnet system are effected.

The field-magnet of the machine B, on the other hand, being stationary and secured to the casing 15, this latter machine has its terminals arranged in the manner usually adopted for ordinary dynamos or motors.

The spur-pinions 6, 7, 8 and 9 may bear any suitable ratio to one another chosen for a given application. For the purpose of an example it may be assumed that they are proportioned as follows:

Pinion 6:30 teeth.
Pinion 7:30 teeth.
Pinion 8:40 teeth and
Pinion 9:20 teeth.

It may further be assumed that the machines A and B are designed in such a manner as to generate the same current, A at 4500 revolutions and B at 2500 revolutions.

Starting from these data, it is possible to determine what happens under different working conditions, assuming that the first motion shaft 1 rotates at a constant speed of 2000 revolutions:—

1. When the second motion shaft 5 is required to be stationary:—

For this condition, the two machines A and B must have their circuits open so that they do not furnish any power or offer any resistance, and so that no power is transmitted through the pinion 6 to the shaft 5.

The shaft 5 and its pinion 6 therefore being stationary, the pinions 7 will be caused to travel round 6. The pinions 8 being integral with 7 will rotate about their shafts 3 at the same speed as the said pinions 7, that is to say one complete revolution for each revolution of the first motion shaft 1 by reason of the ratio 1:1 of the pinions 6 to the pinions 7.

If the ratio of the pinions 8 to the pinion 9 are also 1:1 the pinion 9 and the hollow shaft 10 would remain stationary like the pinion 6 and the second motion shaft 5 but as the said ratio is 2:1, the pinions 8 will impart to the pinion 9 and the shaft 10 a rotation of equal speed but of opposite direction to that of the first motion shaft 1.

2. When reverse rotation of the second motion shaft is required:—

The armature 11 rotating as hereinbefore stated, at 2000 revolutions in the reverse or backward direction and the field magnet 4 at 2000 revolutions in a forward direction, the relative speed is 4000 revolutions; the armature 12 rotating at 2000 revolutions in the reverse or backward direction and the corresponding field magnet 13 being stationary, the relative speed remains 2000 revolutions. If these two machines are now coupled in series, A as a dynamo and B as a motor, the electro-motive force of A will be to the electro-motive force of B as

$$\frac{4000}{4500} \text{ is to } \frac{2000}{2500}$$

As the first exceeds the second, the armatures will accelerate their movement until these two forces become equal, that is to say according to the assumed data, until the reverse or backward speed is 2500 revolutions, which, for example, will give 2500+2000=4500 revolutions for A and 2500 for B. This acceleration is rendered possible owing to the fact that with the same current the couple exerted by B is greater than that exerted by A.

As soon as the reverse or backward speed of the armature has exceeded the forward speed of the engine, the pinion 6 and the shaft 5 will rotate in the reverse or backward direction to the extent of

$$\frac{\text{Reverse or backward speed} - \text{forward speed}}{2} = \frac{2500-2000}{2} = 250 \text{ revolutions.}$$

By the use of the power-transmitting set according to the invention a wide range of speeds is available, rendering the set specially applicable to motor vehicles. The various speeds are secured as follows:—

First speed:—The second motion shaft being stationary and the vehicle standing, let it be assumed that the machine B is again connected in series with the machine A, B being used as a dynamo and A as a motor with its excitation reduced, so that the electro-motive force of B at 2000 revolutions is greater than the counter-electro-motive force of A at 4000 revolutions. The reverse or backward speed of the two armatures will decrease until these two forces will become balanced.

As the pinion 9 no longer rotates in the reverse or backward direction at the same speed as the first motion shaft 1 rotates in the forward direction, the shaft 5 will rotate in the same direction as the primary motor at a speed which, in accordance with the reduction of the excitation will always be between the limits of 0 and half speed of the motor.

2nd Speed:—If the machine B be

short-circuited upon itself, it will act as a magnetic clutch and the pinion 9 will be retained stationary, so that the pinion 6 and the shaft 5 will rotate at half speed in relation to the shaft 1, that is to say, at 1000 revolutions for the speed which has been assumed above.

3rd Speed:—Let it now be assumed that the machine A is connected in series with B in such a manner that A serves as a dynamo and B as a motor, the armature of B having a tendency to rotate in the same direction of the first motion shaft.

The two machines will be balanced when the increased electro-motive force of A has become equal to the counter-electro-motive force of B and as these two forces, owing to the construction of these machines, will be equal when the ratio of the speeds is 4500:2500, the said condition will be secured when the difference of 2000 revolutions distributed between the armatures 11 and 12 is distributed in the proportion:

$$\frac{2000}{7000} \times 4500 \text{ and } \frac{2000}{7000} \times 2500$$

which gives respectively 1285 and 715 revolutions.

The armature 11 will thus rotate at 1285 revolutions in the reverse or backward direction in relation to the field-magnet 4 and the armature 12 at 715 revolutions in the forward direction in relation to the field-magnet 13.

These 715 revolutions represent the actual speed of the pinion 9 which is solid with the said armature.

The speed of the shaft 5 at this moment will therefore be:

$$\frac{2000+715}{2} = 1357 \text{ revolutions in the forward direction.}$$

4th Speed:—The connections remaining the same, the excitation of the field-magnet of the machine B may be reduced in such a way that the above-reasoning, applied to other data, will lead to a speed of 1500 revolutions for the shaft 5.

5th Speed:—If the machine A be short circuited upon itself, the pinion 9 will be stationary in relation to the pinion 8 and, the pinion 7 being unable to rotate, the pinion 6 and the shaft 5 will have a speed equal to that of the first motion shaft 1, and thus a speed corresponding to that of direct coupling in the case of an ordinary transmission gear will be obtained.

The theory hereinbefore set forth has been established without taking into account the relative slipping of parts which with a full load will give a speed slightly lower than the aforesaid theoretical results.

It should be observed that the functions of battery charging and the starting of the internal combustion engine may, according to the invention, be combined in the one apparatus as heretofore, the power transmitting set according to the invention making it possible to provide for the lighting and the starting without having recourse to the independent charging dynamo and the starter usually employed for this purpose upon motor vehicles.

To attain the said result use is made of the electrical machine B (Fig. 1). By cutting out of service the series wound field-magnet provided for its normal power-transmitting function and by switching in a shunt-wound field-magnet a shunt dynamo will be obtained; to complete the system and render the same automatic in action, a regulator and a circuit breaker are added, as shown in the diagram, Fig. 2.

Referring to Figure 2, 16 indicates the supplementary shunt wound field-magnet, and 17 a circuit breaker controlled by a shunt coil 18 connected to the terminals of the dynamo and a series coil 19 traversed by the charging current; the said circuit breaker 17 is kept open by a spring 20, as long as the dynamo armature is stationary or rotates at a speed too low to enable the tension to equal that of the battery. 21 indicates an excitation regulator controlled by a shunt coil 22 connected to the terminals of the dynamo and a series coil 23 traversed by the charging current.

When no current passes through the coils this regulator 21 is kept closed by a spring 24.

25 indicates a switch controlled by the main switch, permitting the necessary connections to secure the excitation in the proper direction for charging the armature 12 rotating, when the vehicle is stationary, in a direction opposed to that of the internal combustion motor and when the latter operates at maximum speed in the same direction as that of the said motor.

The operation of this arrangement may be described as follows:—

If the armature 12 moves in relation to the field-magnets an electro-motive force will be generated; when such force is slightly greater than the tension of the battery, the circuit breaker 17, drawn by the coil 18, will be closed so as to allow the passage of the current and the charging of the battery will thus start. The flux then produced by the coil 19 will reinforce that of the coil 18. If

at a given moment the speed decreases to such an extent that the generated electro-motive force becomes lower than the tension of the battery, the latter will discharge into the dynamo, but as soon as this takes place the flux radiating from the coil 19 will become opposed to that of the coil 18 and this flux of the coil 18 will become insufficient to maintain the circuit breaker 17 closed so that the latter will be opened under the action of the spring 20 and the dynamo will be disconnected from the battery.

If on the contrary, the electro-motive force, owing to an increase of speed, increased considerably, the charging current might become excessive and might damage the battery; however, when the said current exceeds a suitable predetermined limit the flux from the coil 22 and 23 become sufficient to break the circuit at 21 and the excitation of the field-magnet coils 16 is arrested. The electro-motive force at once decreases and tends to become *nil*: as soon as it becomes insufficient to maintain the switch 21 open, the latter will close and as a consequence the electro-motive force will again increase and the same phenomenon of interruption will take place again. This switch 21 having a constant action, the current generated is of an undulatory character, always of the same direction, but practically constant. The coil 22 is designed in such a manner that when the battery is charged, it will act alone and limit the voltage in such a manner that even when there is no battery the lighting may be turned on without risk of "burning" the lamps owing to excessive tension.

As to the starting of the internal combustion motor, when the car is stationary with the brakes applied, if the armatures are caused to rotate in one direction, the motor will rotate in the opposite direction. By connecting the battery directly to the terminals of the machine B in such a manner that the current passes successively through the armature and the series excitation, the said machine will act as a motor and, if care has been taken to make the connections in such a manner that such machine then rotates in a direction opposite to the normal direction of rotation of the motor, the latter will be caused to rotate in the normal direction.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Electrical power-transmitting set, characterized by the interposition between the first motion shaft and the second motion shaft of any convenient planetary gearing system and of two electrical machines, one of which has a rotatable field-magnet and a rotatable armature, while the other has a stationary field-magnet and a rotatable armature, one of the three constituent elements of said planetary gearing system being related both to the first motion shaft and to the said rotatable field-magnet, another to the armature shaft, which is common to both machines and concentric with the second motion shaft, and the third to said second motion shaft, the whole operating in the manner and for the purposes substantially as hereinbefore described.

2. Electrical power-transmitting set, as claimed in Claim 1, characterized by the arrangement and the connection of the electrical elements for any determined approximate speed ratio in such a manner that the electrical effort will be transmitted to the second motion shaft through the medium of the planetary gearing system, whereby the latter is transformed into a change-speed gear with a variable couple.

3. Electrical power-transmitting set, characterized by the combination of: An electrical machine, capable of acting either as a dynamo or a motor and having a rotatable field-magnet and a rotatable armature; a second electrical machine capable of acting either as a dynamo or a motor and having a stationary field-magnet and a rotatable armature; a first motion shaft rigidly connected to the end cover plate of the rotatable casing carrying the field-magnet of the first-named electrical machine; a hollow armature shaft carrying the armatures of both electrical machines; a second motion shaft extending within said hollow shaft; spur-gear on the end of said hollow shaft and said second motion shaft adjacent the end cover of the rotatable casing of the aforesaid first-named electrical machine; an annular series of shafts carried by said rotatable casing; and satellite gearing rotatably mounted on the last named shafts and forming an operative connection between the aforesaid hollow shaft and the aforesaid second motion shaft by engagement with the spur-gear thereon.

4. The method of adapting the electrical power-transmitting set according to Claim 4 to the charging of the battery and the starting of the internal combustion engine, respectively by using one of the electrical machines which has a stationary field-magnet and a rotatable armature and is normally a series-wound machine as a shunt-dynamo, and by using the same machine, as a series-wound

motor rotating in the reverse direction and transmitting its motion through the medium of the planetary gearing system.

5. The electro-magnetic power-transmitting arrangement substantially as and for the purpose hereinbefore described with reference to the accompanying drawing.

Dated this 26th day of October, 1923.

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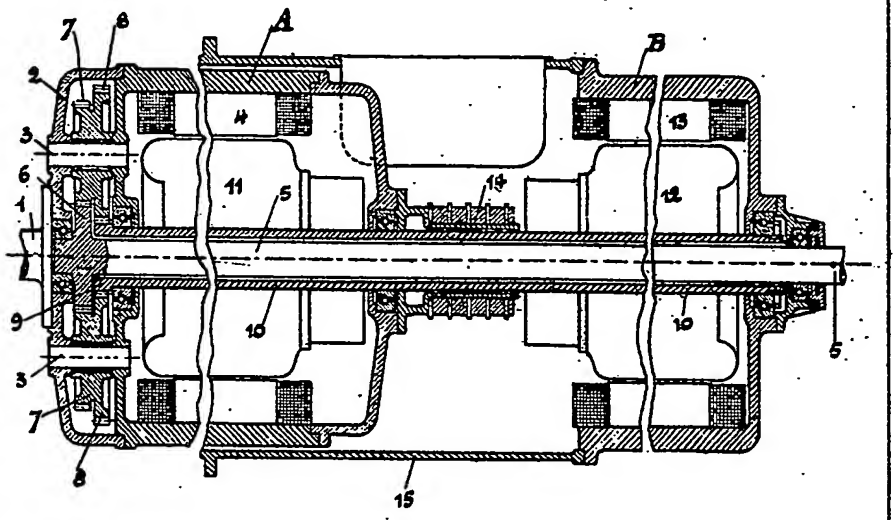

Fig. 1.

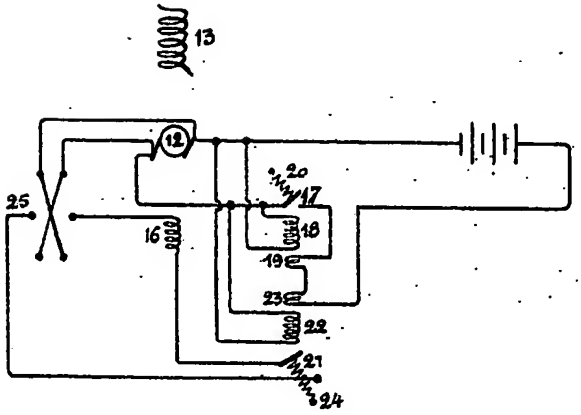

Fig. 2.

Malby&Sons, Photo-Litho